March 1996 Highlights of the Pulsed Power Inertial Confinement Fusion Program

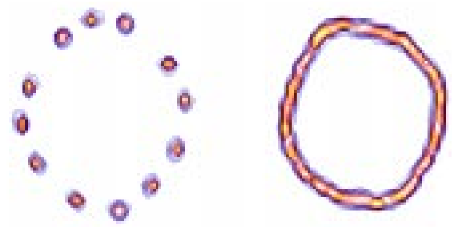

Fig. 1. End-on calculational view of annular array of imploding wires with a) 12 wires and b) 24 wires.

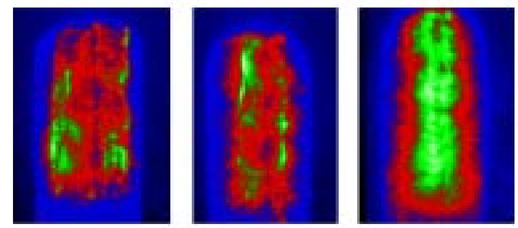

Fig. 2. Framing camera images of wire array implosion onto foam cylinder at 3 ns intervals for Saturn shot 2261.

Components are arriving at the assembly area to begin modifying PBFA II to enable z-pinch-driven implosions (PBFA Z) at higher currents than possible on Saturn. We have decided to increase significantly resources devoted to magnetic implosion research in FY97 while reducing resources devoted to ion beams. We will do ion diode, source, and transport research on SABRE and ALIAS at SNL, on COBRA at Cornell, and on Gamble II at NRL for the next two years rather than alternating between the PBFA-X (extraction) and PBFA-Z modes.

An important quantity that affects the stability of the recent wire-array z-pinch implosions on Saturn and the power increase obtained is the circumferential gap g_c between the wires (*i. e.*, the distance between adjacent parallel wires along a circle). Radiation-hydrodynamics calculations show a smaller gap allows the annular wire array to implode as a continuous cylindrical shell of plasma rather than as discrete wire plasmas (Fig. 1). If the wires are too far apart, each pinches by itself before they meet on axis, resulting in an inhomogenous plasma column. New multi-slotted hardware for stringing the fragile wires has allowed us to decrease the wire-to-wire gap below the 0.6 mm minimum of previous hardware. With the new design, we can also align the wires more precisely along the circumference, without incurring a large error in centering individual wires.

We have begun an experimental effort to develop the dynamic hohlraum concept on Saturn. In this concept, current passes through a high-Z material, creating an imploding plasma (the dynamic hohlraum) that heats a core material and generates and then confines a radiation field that could implode a fuel capsule. This experimental effort is providing critical data on two methods that could create the dynamic hohlraum. In the first, current flow is initiated along a thin layer of high-Z material that is coated on the outside of a low density foam cylinder. This z-pinch configuration is thought to be more insensitive to magnetic Rayleigh-Taylor instabilities, since the Rayleigh-Taylor bubble growth is attenuated throughout the entire implosion by the accretion of the material in the low density foam. In the second method, an annular array of high-Z wires merges to form a plasma shell (as described in the previous paragraph) that implodes for several millimeters before stagnating on a central foam cylinder. In both configurations, the radiation created by the shock waves within the cylindrical system is partially contained by the outer shell of high-Z plasma. In these initial experiments, diagnostics, including framing cameras and filtered x ray diodes, view the silicon aerogel foam along and perpendicular to its axis. Figure 2 shows that the foam core held off the imploding wire plasma and created a hot annular region surrounding the foam core.

Spectroscopic data in the anode-cathode gap of the PBFA-X ion diode show the surprising result that the electric field profile in the vicinity of the anode is flat, which implies $n_e \sim n_i$. The ion current density J_i near the anode as calculated from the observed electric field profiles also does not require high ion enhancement. Our diode models, on the other hand, assume $n_e << n_i$. Recently we did Monte Carlo and particle-in-cell (QUICKSILVER) simulations that allow for electron reflectivity and, hence, $n_e \sim n_i$. These calculations suggest, however, that even for high electron reflectivity, a simulation including electron backscatter gives substantially the same result as a simulation not including backscatter. Fortunately, we have developed a new tool, the active spectroscopic probe, for which the Doppler effect is quite small. We should therefore be able to improve our diode models by simultaneously mapping MV/cm electric fields and Tesla magnetic fields at nanosecond time scales for millimeter length scales in the gap.

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